Earth Sciences Architecture for Atmospheric Chemistry, Earth Radiation Balance, and Geomagnetism Measurements

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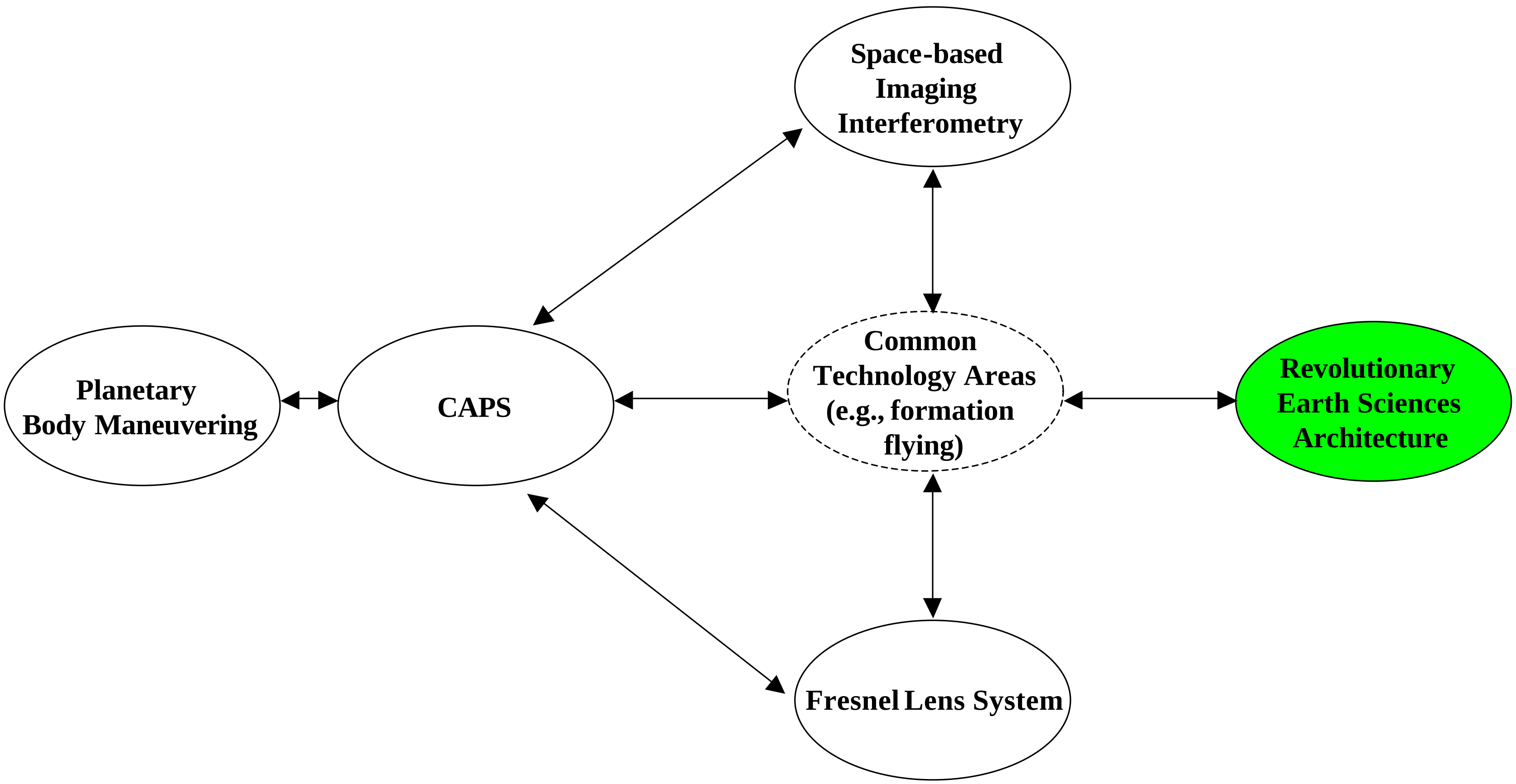
Relationship to Other In-Space Remote Sensing Studies



Focused on Earth Science Measurements from the Edge of Space

Background and Motivation

- **Significant potential Earth science benefits from stratospheric platforms with**
  - **Long duration (> 100 days)**
  - **Autonomous coordination (data relay, position correction, and notification in the event of problems)**
  - ***In-situ* measurement capabilities**
- **Architecture for such measurements provides unique and challenging opportunities**

Potential Benefits

- **Low-cost, high-altitude (35 km) platform above 99% of Earth's atmosphere**
- ***In-situ* measurements eliminate assumptions inherent in remote sensing of same quantity**
- **Long-life platform provides high accuracy (through averaging) if errors are random**
- **Instrument recovery allows post-flight verification**
- **Easy upgrade to new technologies: recover and re-launch**
- **Validation of space-borne instruments**

Potential Earth Science Applications

- **Atmospheric Chemistry**
  - **Few actual profiles of chlorine and bromine (< 1 balloon launch per year)**
  - **100-day flight would provide snapshot of evolving stratospheric trace gas structure**
  - **Stratospheric vertical profiles of trace gases Cl_y, No_y, Br_y, H, O_3**
  - **Current space-based remote observations of ozone and ozone-destroying chemicals lack needed vertical resolution and continuity**
  - **A global network of stratospheric platforms could provide the opportunity to make continuous, detailed vertical profile measurements of ozone and other atmospheric constituents over a long period of time, 1 year or more, and at unprecedented spatial and temporal scales**

Potential Earth Science Applications

- **Earth Radiation Balance**
  - **Fluxes at the top-of-the-atmosphere are primary drivers for climate change**
  - **Satellites measure radiance, not flux**
  - **Dynamics of the flux (hourly and daily synoptic variation) are unknown**
  - **100 platforms around the globe would measure flux directly and provide dynamics**
  - **Upwelling shortwave (0.2 to 3 μm wavelength) and longwave (4 to 50 μm) radiation flux**
  - **The thermal IR and solar radiative fluxes (that enter into earth radiation balance) are the primary drivers of the climate and global change**
  - **A global network of stratospheric platforms could provide the opportunity to make direct measurements of fluxes**
  - **By making these measurements from a stratospheric location, scientists could provide conclusive answers to fundamental questions like “is the Earth warming up?” and “is global cloudiness increasing or decreasing?”**

Potential Earth Science Applications

- **Geomagnetism**

  - Non-uniform distribution of existing, land-based observatories
  - Stratospheric platforms could act as proxies for geomagnetism observatory and provide data over oceans
  - Accurate data needed for mineral and petroleum exploration
  - Measurements of the Earth's magnetic field over various temporal and spatial scales offer an opportunity to study the Earth's interior and it's motions by identifying sources of the field
  - Observations of magnetic field variations over long time scales (years) would help to detect magma displacements in the Earth mantle and potentially lead to forecasts of earthquake and volcanic eruptions
  - A global network of stratospheric platforms would bridge the gap between surface and satellite measurements; provide observations with high resolution and high signal-to-noise ratio; provide global and regional coverage; and lead to development of three-dimensional maps of the Earth's magnetic field and its sources.

Key Development Challenges

- Long-duration (>100 days) flights
- Steerable platform (into and out of polar vortices)
- Launch location and time flexibility
- Reliable operation and payload recovery
- Precise orientation and pointing knowledge
- Power

Study's Objectives

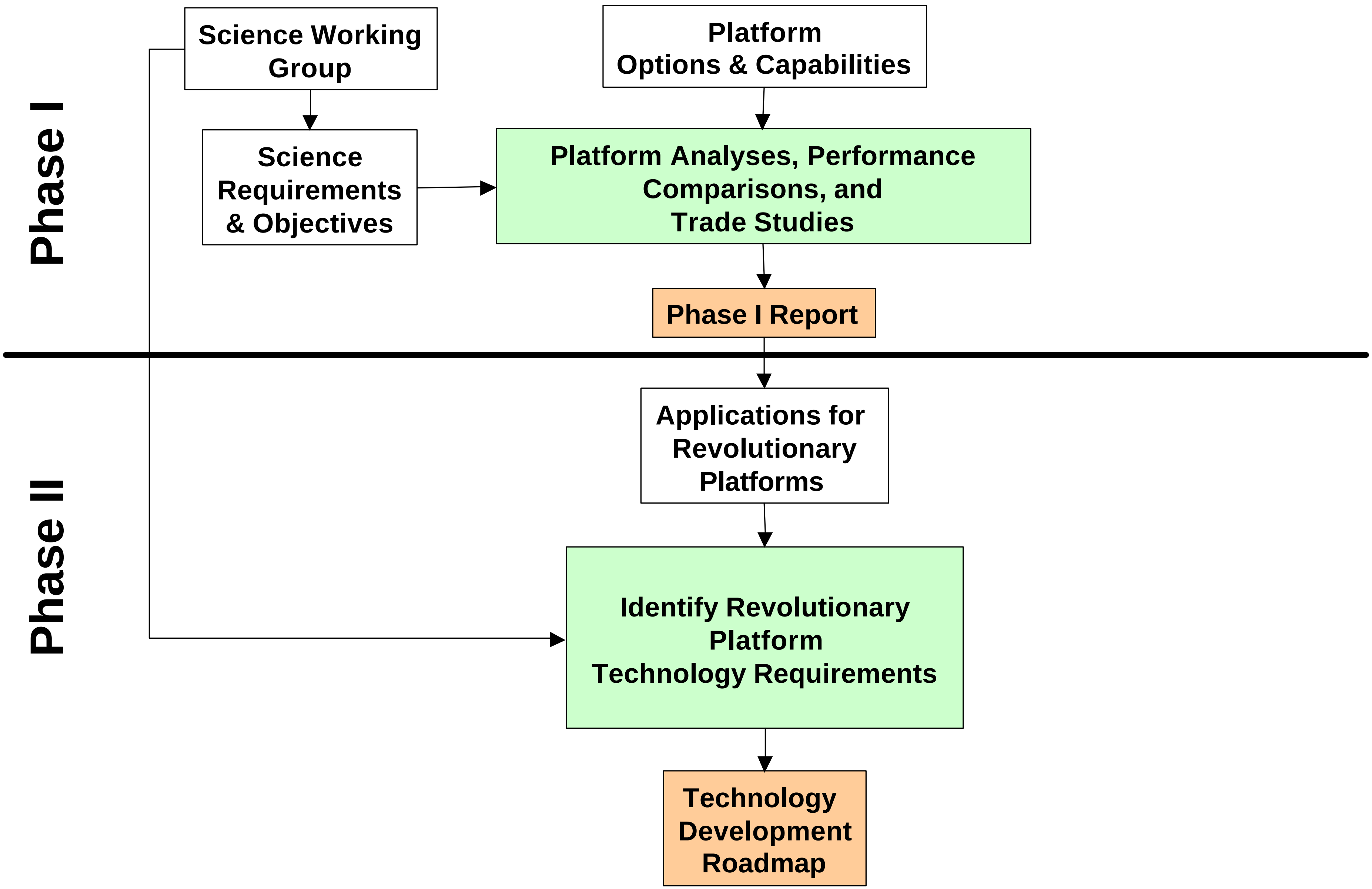
- **Phase I**
  - **Identify science goals, as they relate to NASA's Earth Science Research Strategy, for stratospheric platforms**
  - **Identify and investigate a range of advanced platforms required for making Earth science measurements in the upper stratosphere**
- **Phase II**
  - **Identify the revolutionary technologies necessary for each platform needed to make the desired measurements**

Phased Approach

- **Phase I: Evaluate Architecture Options for Earth Science**
  - **Systems perspective**
  - **Examine various platform alternatives**
  - **Identify strengths of platform systems for meeting science objectives**
  - **Identify mission applications that deserve further study**

- **Phase II: Technology Roadmap**
  - **10-15 year time frame**
  - **Infrastructure needs**
  - **Technology needs**

Approach


Phase I
Phase II
Science Working Group
Science Requirements & Objectives
Platform Options & Capabilities
Platform Analyses, Performance Comparisons, and Trade Studies
Phase I Report
Applications for Revolutionary Platforms
Identify Revolutionary Platform Technology Requirements
Technology Development Roadmap

Summary

- NASA's ESE would benefit tremendously from long-duration autonomously coordinated *in-situ* measurements in the stratosphere
- Measurement architecture is unique and challenging
- Architecture shares technology areas with other In-Space Remote Sensing RASC studies
- Development of the architecture would revolutionize Earth science by answering fundamental questions about
  - Atmospheric chemistry
  - Earth radiation balance
  - Geomagnetism